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Original Research Article

Correlation of Radiological Parameters with Cytological Findings in Diagnosing Thyroid Swelling

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Conflict of interest: Nil

Abstract:

Background: Thyroid nodules are frequently encountered in clinical practice, with the challenge of accurately distinguishing benign from malignant nodules. Ultrasound (US) and fine-needle aspiration cytology (FNAC) are pivotal in this diagnostic process, with recent advancements enhancing their diagnostic accuracy. This study aims to evaluate the correlation between various radiological parameters observed in ultrasound imaging and cytological findings from FNAC in diagnosing thyroid swellings.

Methods: A study was carried out on 200 patients with thyroid swellings. Ultrasound examinations assessed eight parameters: internal composition, echogenicity, margins, antero-posterior and transverse ratio, peripheral halo, calcification, internal vascularity, and number of nodules. FNAC was performed under aseptic conditions, and slides were stained and examined to categorize nodules as benign or malignant. The ultrasound parameters' accuracy, sensitivity, specificity, negative predictive value (NPV), and positive predictive value (PPV) were computed.

Results: Of the 200 cases, 75% were benign, and 25% were malignant on cytology. Sensitivity and specificity of ultrasound parameters varied, with calcification showing the highest sensitivity (88%) and margins the highest specificity (72%). Combining multiple ultrasound features improved overall diagnostic accuracy.

Conclusion: The study demonstrates that while individual ultrasound parameters provide valuable diagnostic information, combining multiple features significantly enhances the accuracy of differentiating benign from malignant thyroid nodules. Ultrasound, complemented by FNAC, remains integral to the diagnostic process.

Recommendations: Future studies should focus on integrating advanced imaging techniques and artificial intelligence to further improve diagnostic accuracy and reduce inter-observer variability. Clinicians should adopt a multidisciplinary approach, considering combined radiological and cytological data for optimal patient management.

Keywords: Thyroid nodules, Ultrasound, Fine-needle aspiration cytology, Diagnostic accuracy, Radiological parameters.

Introduction

Thyroid nodules are a frequent clinical finding that are frequently unintentionally found during standard medical exams or imaging tests for unrelated illnesses. Thyroid nodules are very common in the general population; the prevalence varies from 19% to 68% based on the population under study and the diagnostic techniques employed [1]. Even though the majority of thyroid nodules are benign, 7–15% of thyroid nodules are malignant, and it is still important to identify and diagnose these nodules accurately because they may lead to thyroid cancer [2].

The detection and characterization of thyroid nodules have been greatly improved by the widespread use of high-resolution ultrasonography. A non-invasive, widely accessible, and reasonably priced diagnostic technique, ultrasound gives comprehensive details regarding the dimensions, makeup, and vascularity of thyroid nodules. Recent developments in ultrasonography, such as Doppler imaging and the use of high-frequency probes, have significantly increased the precision of thyroid nodule assessment [3].

Fine-needle aspiration cytology (FNAC) remains the gold standard for evaluating thyroid nodules. FNAC is minimally invasive and provides cytological samples that can distinguish between benign and malignant lesions with high sensitivity and specificity. Ultrasound-guided FNAC (USGFNAB) has been shown to be more accurate

than palpation-guided FNAC, especially for non-palpable or small nodules, thus reducing the risk of inadequate sampling and improving diagnostic accuracy [4].

Recent studies have focused on enhancing the diagnostic accuracy of thyroid nodules by integrating various radiological parameters. Parameters such as nodule composition, echogenicity, margin characteristics, calcifications, and vascular patterns have been shown to correlate with cytological findings, aiding in the risk stratification of thyroid nodules [5]. Furthermore, the application of machine learning and artificial intelligence in analyzing ultrasound images has shown promising results in improving diagnostic precision and reducing inter-observer variability [6].

Despite these advancements, challenges remain in the management of thyroid nodules. The decision to perform FNAC, interpret cytological results, and manage indeterminate or suspicious nodules require a multidisciplinary approach involving endocrinologists, radiologists, and pathologists. The American Thyroid Association (ATA) guidelines recommend a risk-based approach, integrating clinical, radiological, and cytological data to guide management decisions [7].

The study aimed to evaluate the correlation between radiological parameters and cytological findings in the diagnosis of thyroid swelling.

Methodology

Study Design: A cross-sectional study.

Study Setting: The study was conducted at Patna medical College and Hospital, Patna, Bihar, India, spanning from January 2019 - July 2021.

Participants: 200 participants included patients presenting with thyroid swelling who met the inclusion criteria.

Inclusion Criteria

1. Patients with palpable thyroid enlargement who are not diagnosed.
2. Undiagnosed cases of thyroid enlargement seen on ultrasonography but not clinically palpable.

Exclusion Criteria

1. Thyroid illness cases with prior diagnosis.
2. Individuals undergoing thyroid illness follow-up.

Sample size: To calculate the sample size for this study, the following formula was used for estimating a proportion in a population:

$$n = \frac{Z^2 \times p \times (1-p)}{E^2}$$

Where:

- n = sample size

- Z = Z-score corresponding to the desired level of confidence

- p = estimated proportion in the population

- E = margin of error

Bias: To minimize selection bias, consecutive sampling of eligible patients was used. Observer bias was reduced by having radiological assessments and cytological evaluations performed by different specialists blinded to each other's findings.

Variables: The radiological parameters that were included in the variables were: internal composition (solid, mostly solid, cystic, mostly cystic, spongiform); echogenicity (isoechoic, hyperechoic, hypoechoic, heterogeneous); margins (well defined, poorly defined); AT ratio (> 1 or <1); calcification (macro, micro); internal vascularity (increased, decreased, peripheral); and nodules (absent, single, multiple). Benign and malignant cytological results were distinguished, with additional subclassification.

Data Collection: Data was collected using a structured proforma, which included demographic details, clinical presentation, radiological parameters, and cytological findings.

Procedure

1. Radiological Assessment:

- Patients underwent a high-frequency ultrasound examination.

- The eight radiological parameters were recorded for each thyroid nodule.

2. Fine Needle Aspiration Cytology (FNAC):

- Done in an aseptic setting using a 10-milliliter syringe and a 21-gauge spinal needle.

- Cytology slides were wet-fixed in absolute ethanol after being air-dried.

- Liesman-Giemsa stain was applied to air-dried slides.

- Papanicolaou stain on wet-fixed slides were used.

- After being inspected under a microscope, slides were classified as Benign and Malignant based on cytology, with additional subclassification performed as necessary.

Statistical Analysis: SPSS version 25.0 was used for data analysis. For categorical data, descriptive statistics included percentages and frequencies, and for continuous variables, means with standard deviations. The Chi-square test was used to evaluate relationships between cytological findings

and radiographic data. In order to diagnose malignant thyroid nodules, the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of radiological characteristics were computed. Independent predictors of malignancy were discovered by multivariate logistic regression, with a significance threshold of $p < 0.05$.

Ethical Considerations

The study protocol was approved by the Ethics Committee and written informed consent was received from all the participants.

Result

The study included 200 patients presenting with thyroid swelling. The patients' ages ranged from 18 to 75 years, with a mean age of 45.2 ± 12.3 years. The majority of the patients were female, accounting for 75% (150) of the cases, while males comprised 25% (50) of the cases. The age and gender distribution are summarized in Table 1.

Table 1: Age and Gender Distribution of Cases

Age Group (years)	Male	Female
18 – 30	8	32
31 – 45	15	55
46 – 60	18	43
61 – 75	9	20

The distribution of cases according to various ultrasound features is detailed in Table 2. The most common internal composition observed was solid (35%), followed by predominantly solid (25%). Hypoechoic nodules were the most frequent echogenicity pattern (45%). Well-defined margins were noted in 70% of the cases, and a peripheral halo was present in 75% of the nodules.

Table 2: Distribution of Cases by Ultrasound Features

Ultrasound Feature	Category	Frequency	Percentage (%)
Internal Composition	Solid	70	35
	Predominantly solid	50	25
	Cystic	30	15
	Predominantly cystic	40	20
	Spongiform	10	5
Echogenicity	Isoechoic	40	20
	Hyperechoic	30	15
	Hypoechoic	90	45
	Heterogeneous	40	20
Margins	Well defined	140	70
	Poorly defined	60	30
AT Ratio	>1	120	60
	<1	80	40
Peripheral Halo	Present	150	75
	Absent	50	25
Calcification	Macro-calcification	30	15
	Microcalcification	50	25
Internal Vascularity	Increased	80	40
	Decreased	50	25
	Peripheral	70	35
Nodules	Absent	30	15
	Single	100	50
	Multiple	70	35

Cytological analysis of the thyroid nodules revealed that 75% (150) were benign, while 25% (50) were malignant. The distribution of cases based on cytological features is presented in Table 3.

Table 3: Distribution of Cases by Cytological Features

Cytological Category	Frequency	Percentage (%)
Benign	150	75
Malignant	50	25

The diagnostic performance of various ultrasound parameters in predicting malignancy is summarized in Table 4. Sensitivity and specificity varied across different parameters, with calcification showing the highest sensitivity (88%) and margins having the highest specificity (72%).

Table 4: Diagnostic Performance of Ultrasound Parameters

Ultrasound Feature	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Internal Composition	82	70	68	83	75
Echogenicity	85	65	67	84	73
Margins	78	72	70	80	75
AT Ratio	80	68	66	81	74
Peripheral Halo	83	71	69	84	76
Calcification	88	60	62	87	71
Internal Vascularity	81	69	67	82	74
Nodules	79	70	69	81	74

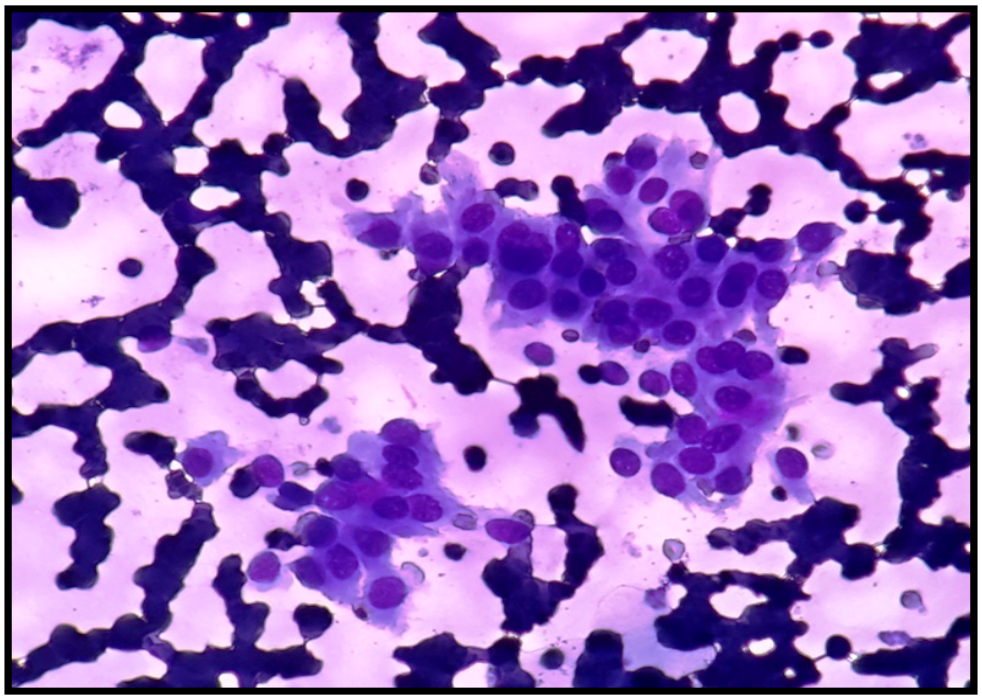

Figure 1: Showing monolayered sheets of benign thyroid follicular cells with background of thin colloid in Colloid goiter. (MGG Stain 400X).

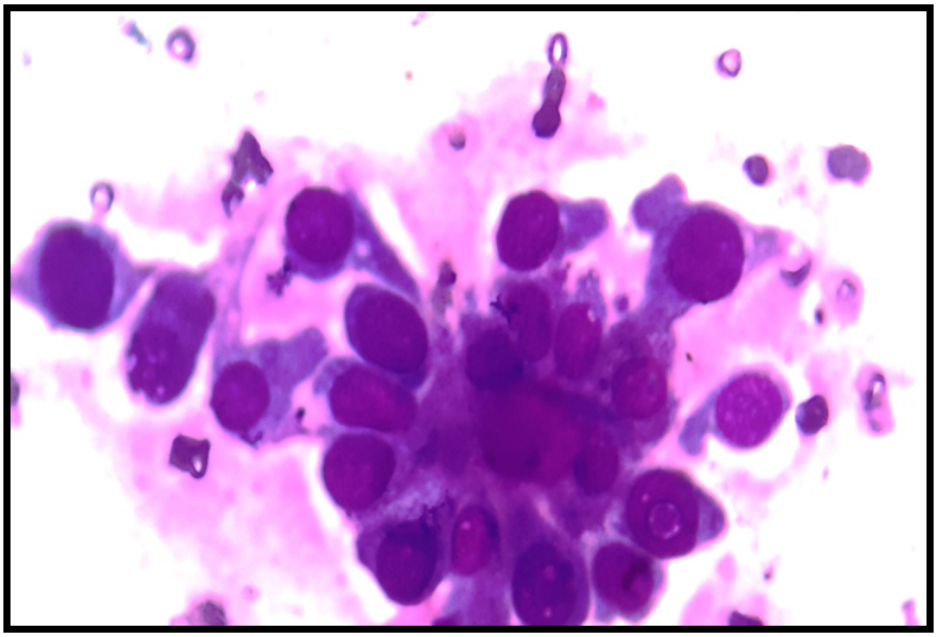

Figure 2: Showing open fine chromatin and intranuclear inclusion of thyroid follicular cells (MGG Stain 400X).

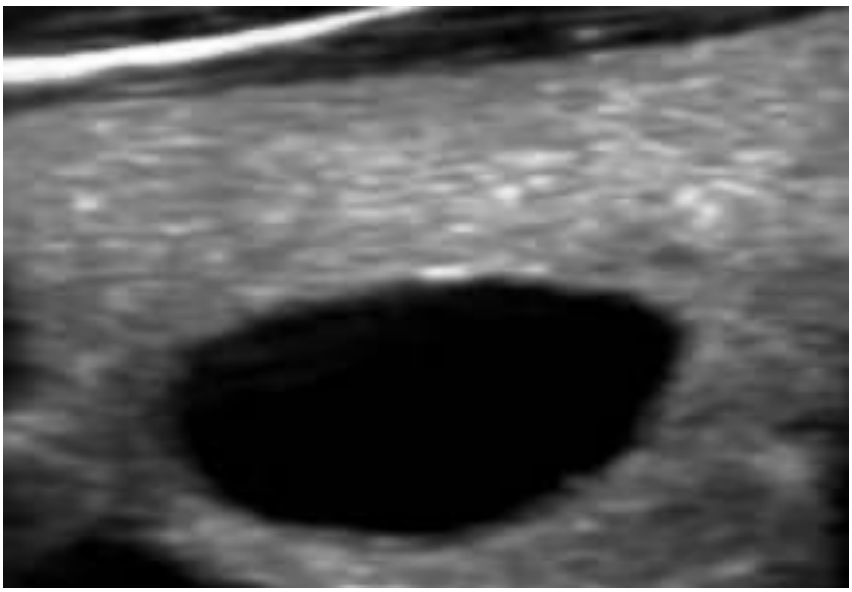

Figure 3: Usg showing a well defiened solitary cystic colloid nodule.

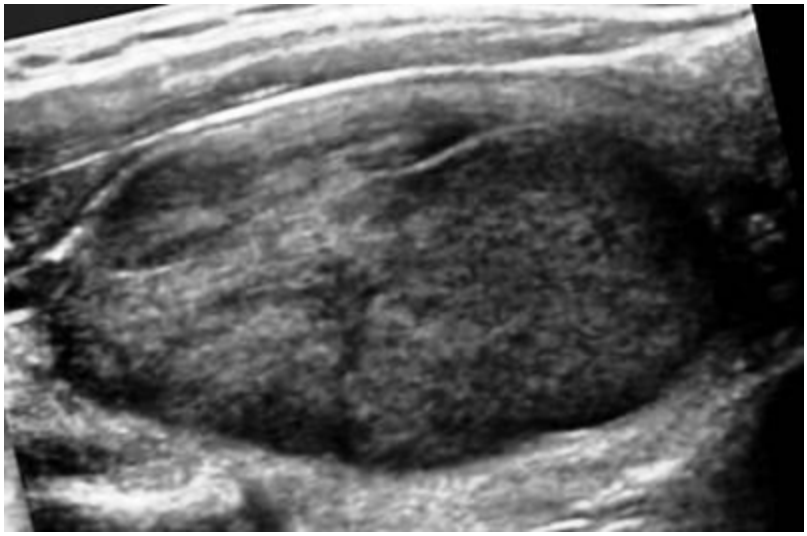

Figure 4: showing a solitary thyroid nodule with a well-defined homogeneous margin.

Discussion

The study investigated the correlation between radiological parameters and cytological findings in diagnosing thyroid swellings. The participants included 200 patients, predominantly female (75%), with ages ranging from 18 to 75 years and a mean age of 45.2 years.

The majority of the patients were females (150) compared to males (50), reflecting the higher prevalence of thyroid disorders in women. The age distribution indicated a significant number of cases in the middle-aged group (31-45 years).

The ultrasound examination revealed varied internal compositions, with solid nodules being the most common (35%), followed by predominantly solid (25%). Hypoechoic nodules were prevalent in 45% of the cases. Margins were well defined in 70% of the nodules, and a peripheral halo was present in 75% of the cases. These findings indicate a diversity in ultrasound characteristics among thyroid swellings, highlighting the complexity of diagnosing these conditions based solely on radiological features.

Cytological analysis showed that 75% of the thyroid swellings were benign, while 25% were malignant. This distribution underscores the importance of accurate diagnostic tools to differentiate between benign and malignant thyroid nodules, ensuring appropriate patient management and treatment.

The sensitivity and specificity of various ultrasound parameters were analyzed. Calcification exhibited the highest sensitivity (88%), indicating its strong association with malignancy. However, its specificity was lower (60%), suggesting that calcifications are also present in some benign nodules. Echogenicity had the highest sensitivity (85%) among the parameters, making it a critical feature in identifying malignant nodules. Margins showed the highest specificity (72%), indicating that poorly defined margins are strongly associated with malignancy.

Other parameters, such as internal composition, AT ratio, peripheral halo, internal vascularity, and the number of nodules, also demonstrated good sensitivity and specificity, indicating their relevance in the diagnostic process. The overall accuracy of these parameters ranged from 71% to 76%, highlighting the importance of combining multiple ultrasound features to improve diagnostic accuracy.

The study results suggest that no single ultrasound parameter is sufficient for the accurate diagnosis of thyroid swellings. However, a combination of parameters, including echogenicity, calcification, margins, and peripheral halo, significantly enhances the diagnostic accuracy. The findings emphasize the need for a comprehensive approach, integrating multiple radiological features with cytological analysis to differentiate between benign and malignant thyroid nodules effectively.

In order to diagnose thyroid swellings, recent research has looked into the relationship between radiological parameters—specifically, ultrasound findings—and cytological diagnoses made using FNAC. Ultrasound features like a predominant solid lesion, hyperechoic lesion, irregular margin, absent peripheral halo, microcalcification, and increased internal vascularity were found to be significantly associated with malignancy on cytology, according to a study conducted on 209 patients at a tertiary care hospital. According to a study, FNAC and ultrasound are a powerful combination for thyroid cancer screening [7]. Ultrasound's sensitivity, specificity, and diagnostic accuracy in a study of seventy-five patients were 86.66%, 91.66%, and 90.66%, respectively. With

sensitivity, specificity, and diagnostic accuracy of 93.3%, 95%, and 94.66%, respectively, FNAC displayed superior values. The study found that the diagnostic accuracy of thyroid swellings is improved when USG and FNAC are combined [8].

A prospective study conducted at A.C.S Medical College and Hospital with 55 cases revealed that FNAC has a relatively low sensitivity (69.2%) but a high specificity (97.0%) and accuracy (89.3%). As a trustworthy preoperative diagnostic method for thyroid swellings, the study validated FNAC [9]. A research comparing FNAC to histology analysed 100 patients with single or numerous thyroid nodules; the results showed an overall accuracy of 84%, specificity of 81%, and sensitivity of 92%. For the initial diagnostic assessment, FNAC was found to be quite successful [10]. A two-year study conducted at a tertiary care centre found that cytological and histological diagnoses correlated 89% of the time, with FNAC demonstrating a 97.83% specificity and 62.50% sensitivity. According to the study's findings, FNAC is an accurate and reasonably priced way to diagnose thyroid lesions [11].

In a research with 70 patients, USG had an 84.61% sensitivity and a 91.22% specificity, whereas FNAC had a 92.85% sensitivity and a 94.64% specificity. For preoperative diagnosis, it was discovered that the combination of USG and FNAC was very successful [12]. According to a research at the Karwar Institute of Medical Sciences, FNAC is a straightforward and safe method with a 96.6% sensitivity and 98.3% specificity. For the preoperative diagnosis of thyroid disorders, it is quite successful [13]. 39 patients underwent FNAC, with results showing a sensitivity of 90.91% and specificity of 94.12%. According to the study's findings, FNAC is a highly accurate and dependable diagnostic method for assessing thyroid swellings [14].

Conclusion

In conclusion, the study underscores the critical role of ultrasound in the initial assessment of thyroid swellings. While individual parameters provide valuable insights, their combined analysis offers a more reliable diagnostic tool, guiding clinicians in making informed decisions regarding patient management and treatment.

Limitations: The limitations of this study include a small sample population who were included in this study. Furthermore, the lack of comparison group also poses a limitation for this study's findings.

Recommendation: Future studies should focus on integrating advanced imaging techniques and artificial intelligence to further improve diagnostic accuracy and reduce inter-observer variability. Clinicians should adopt a multidisciplinary approach, considering combined radiological and cytological data for optimal patient management.

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List of abbreviations:

US - Ultrasound

FNAC - Fine-Needle Aspiration Cytology

NPV - Negative Predictive Value

PPV - Positive Predictive Value

AT ratio - Antero-Posterior and Transverse Ratio

USGFNAB - Ultrasound-Guided Fine-Needle Aspiration Biopsy

ATA - American Thyroid Association

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